

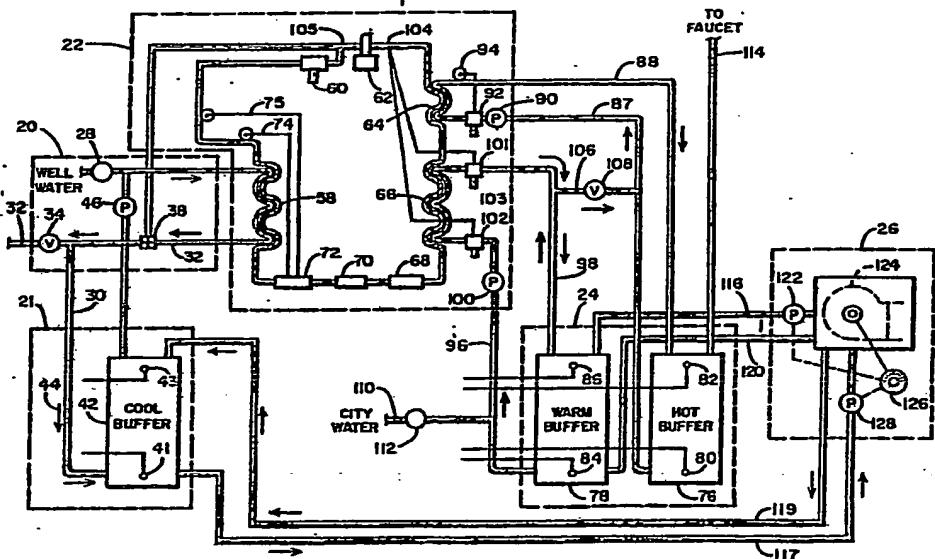


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁴ :		(11) International Publication Number:	WO 89/04443
F25D 17/02, F25B 1/10	A1	(43) International Publication Date:	18 May 1989 (18.05.89)

(21) International Application Number:	PCT/US87/02891	Published
(22) International Filing Date:	3 November 1987 (03.11.87)	<i>With international search report.</i>
(71)(72) Applicant and Inventor:	DITTELL, Edward, W. [US/US]; 9108 North 31st Avenue, New Hope, MN 55427 (US).	
(74) Agents:	SJOQUIST, Paul, L. et al.; Palmatier & Sjquist, 2000 Northwestern Financial Center, 7900 Xerxes Avenue South, Minneapolis, MN 55431 (US).	
(81) Designated States:	AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.	

(54) Title: HEAT ENERGY STORAGE AND TRANSFER APPARATUS



(57) Abstract

A system for preferably utilizing conventional well water as a heat energy source or sink medium, in combination with a heat exchanger (58) and water storage tank (42), wherein heat is extracted from the well water by the heat exchanger and the cooled well water is transferred to the storage tank (42) for cooling purposes (26), and the heat exchanger (58) is coupled to further heat exchangers (64, 66) respectively coupled to warm and hot water storage tanks (78, 76), for transferring heat from the heat exchanger medium into a warm storage tank (78), and for transferring superheated heat from the heat exchanger medium into a hot storage tank (76), respectively utilized for warm water heating (26) and for delivery of hot water (114) for direct use. The well water cooling system is in liquid isolation from the heat transfer fluid medium, and is further in liquid isolation from the respective warm and hot water storage and delivery systems.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT Austria	FR France	ML Mali
AU Australia	GA Gabon	MR Mauritania
BB Barbados	GB United Kingdom	MW Malawi
BE Belgium	HU Hungary	NL Netherlands
BG Bulgaria	IT Italy	NO Norway
BJ Benin	JP Japan	RO Romania
BR Brazil	KP Democratic People's Republic of Korea	SD Sudan
CF Central African Republic	KR Republic of Korea	SE Sweden
CG Congo	LI Liechtenstein	SN Senegal
CH Switzerland	LK Sri Lanka	SU Soviet Union
CM Cameroon	LU Luxembourg	TD Chad
DE Germany, Federal Republic of	MC Monaco	TG Togo
DK Denmark	MG Madagascar	US United States of America
FI Finland		

-1-

HEAT ENERGY STORAGE AND TRANSFER APPARATUS

Background of the Invention

The present invention relates to a system for transferring heat derived from a liquid source, and for storage of liquid involved in the heat transfer process in at least three energy storage tanks maintained at respective different temperature operating ranges.

My prior art U.S. Patent 4,382,368 discloses a geothermal hot water system including a hot water tank and a warm water tank which are heated independently of each other by a closed-loop Freon system. The system includes a main condenser which heats water for the warm water tank and a desuperheating condenser which heats water for the hot water tank, and where the Freon passes through a water evaporator which is typically heated by well water, or energy recovered from cooling type processes. The Freon system is a closed-loop system, which passes the well water through the water evaporator but does not otherwise utilize the well water in the heating system. The warm water tank and the hot water tank are independently supplied through a potable water system, such as a city water supply system. By utilizing a warm water tank and a hot water tank there is provided energy storage reservoirs for respective warm and hot water delivery, and the powered components operable with the closed-loop Freon system can be scaled to deliver average heating needs rather than peak demand heating needs.

My U.S. Patent 4,633,676 expands upon the concepts disclosed in the foregoing patent, by placing an energy transfer apparatus into the well water circulation loop, to thereby utilize well water or cooled well water in conjunction with this energy transfer system to deliver a cooling capability, i.e. cooling air, on a demand basis. The heat energy removed from the well water source results in a drop in well water temperature at the heat

-2-

exchanger output, and this lowered temperature well water is passed through a heat transfer medium such as a radiator and fan configuration, to thereby provide cooled air for demand delivery.

Summary of the Invention

The present invention represents an improvement over the foregoing patents by providing a liquid storage tank, referred to herein as a cool buffer, coupled to the liquid delivery system and the closed-loop heat exchanger, in order that cooled liquid may be stored for subsequent delivery to an energy transfer medium, referred to herein as an energy handler, for cooling purposes. The cool buffer is particularly useful under conditions of limited direct use of ground water. For example, in areas where the ground water is too warm for direct use in cooling, where large numbers of energy handlers would present control problems without a cool buffer, or where limited quantities of ground water are available. The cool buffer would also allow the use of the system with city water where, as in prior art systems, the use of city or treated water would not be economical. The energy handler may be a single device usable for both heating and cooling, coupled through suitable valving to a warm liquid storage tank, referred to herein as a warm buffer, for heating purposes and to the cool buffer for cooling purposes. The power for driving the entire system is derived from one or more closed-loop refrigeration sections, referred to herein as power packs, scaled to provide sufficient power to drive the system according to the average energy demand needs of the individual energy handlers, rather than according to the peak energy demand needs of the system as is common with the prior art systems. For descriptive purposes herein, the invention will be described in the context of well water and city water sources.

-3-

The invention finds particular utility in building layouts having more than four different heating and cooling zones, wherein an energy handler may be placed within each heating/cooling zone, and all energy handlers are coupled to a central power pack/buffer equipment room. In such installations multiple power packs may be staged to deliver incremental levels of energy for heating and cooling, to thereby tailor the energy delivered to average system demand rather than to peak system demand. In such systems the power packs cycle on demand from the various buffers, typically at the rate of 2-4 times per day, rather than present art systems which typically cycle at peak demand at the rate of 4-6 times per hour.

Brief Description of the Drawings

FIG. 1 is a schematic diagram of the apparatus of the present invention;

FIG. 2 is a schematic diagram of a heating/cooling section;

FIG. 3 is a schematic diagram of a modular form of the apparatus of the present invention;

FIG. 4 shows a perspective view of a construction which advantageously utilizes the invention;

FIG. 5 shows a floor plan of the construction of FIG. 4;

FIG. 6 shows a further floor plan of a further portion of the construction of FIG. 4; and

FIG. 7 shows a floor plan of a typical room of the construction of FIG. 4.

Detailed Description of the Preferred Embodiment

The energy transfer system of the present invention is schematically illustrated in FIG. 1. The invention includes a source water section 20, a cool energy storage section 21, a refrigeration section 22, a warm energy storage section 24, and a heating/cooling section 26. It

-4-

is to be appreciated that the present invention may be constructed in modular form, generally according to the layout of FIG. 1. One or more of each of the sections 21, 22, 24 and 26 are combinable to fulfill the heating and/or cooling requirements of a facility or building.

The source water section 20 supplies water from a well or other water source through conduit 28 for heat transfer therefrom by refrigeration section 22. The source water may be potable or may be contaminated, the quality not being of any particular importance with respect to the invention, since the source water is never mixed with any of the other water or liquids used in connection with the invention. In addition, the source water may be any industrial liquid from which heat can be extracted, or may be shallow well water containing pollutants. An expensive well providing clean, deep well water obtained from an aquifer is not needed, although it is preferable that the temperature of the source water is in the range of 40° F.- 90° F.

From the source water section 20 the well water is conveyed to a cool energy storage section 21 through conduit 30. Alternatively, the water may be diverted, if the cool buffer is already cooled sufficiently, through conduit 32 to a drain or other disposal site. The flow of well water to the cool energy storage section 21 is regulated by a solenoid valve 34, or other control valve, located in conduit 32. The cool energy storage section 21 includes a cool buffer 42, into which the well water flows through conduit 30 as indicated by the arrow 44. A pump 46 recirculates warmer water from the top of buffer 42 back into the well water conduit 28 for recirculation into the refrigeration section 22. An optional check valve 40 in conduit 28 limits the direction of well water flow, as shown by the arrow 48.

-5-

The refrigeration section 22 preferably includes at least an evaporator 58, an accumulator 60, a compressor 62, a desuperheating condenser 64, a main condenser 66, a receiver 68, a filter dryer 70 and a thermal expansion valve 72, collectively referred to herein as a power pack 22. The power pack 22 is described in my U.S. Patent No. 4,382,368, which is incorporated by reference herein. The evaporator 58 is preferably a coaxial double tube heat exchanger wherein the well water flows through an outer conduit and the refrigerant (Freon) flows through an inner conduit, evaporating and extracting heat from the well water. Similarly, the desuperheating condenser 64 and the main condenser 66 are preferably also coaxial double tube heat exchangers with the refrigerant flowing through the outer conduit, and water flowing through the inner conduit, with heat being transferred from the refrigerant to the water in the inner conduit. The desuperheating condenser 64 and the main condenser 66 are connected in series, with the superheat being extracted from the refrigerant in the desuperheating condenser 64 and the remaining heat being extracted from the refrigerant by the phase change in the main condenser 66. A thermal expansion valve 72 is positioned upstream of the evaporator 58, and is operated through a temperature sensor 74 and a pressure sensor 75 positioned downstream of the evaporator 58, so that the evaporator 58 is operated at maximum efficiency.

The warm energy storage section 24 preferably includes a hot water tank 76, referred to herein as hot buffer 76, and a warm water tank 78, referred to herein as warm buffer 78. Aquastats 80 and 82 are provided for buffer 76, and aquastats 84 and 86 are provided for buffer 78. Aquastats 80, 82, 84 and 86, upon sensing water temperature below predetermined individually

-6-

selected temperatures, activate compressor 62. Water from the hot buffer 76 is conveyed through conduit 87 through the inner conduit of the desuperheating condenser 64, and back through a return conduit 88 which returns the water back to the top of buffer 76. A pump 90 provides the motive force to pump the water from the bottom of buffer 76 to the desuperheating condenser 64 and back to the top of buffer 76. A modulating valve 92 controls the flow of water through the desuperheating condenser 64 by way of a temperature sensor 94, preferably positioned upstream of the desuperheating condenser 64.

The warm buffer 78 is connected by conduit 96 to the inner conduit of the main condenser 66 for extracting heat from the refrigerant, and the heated liquid is transported back to the top of buffer 78 through conduit 98. A pump 100 provides the motive force for pumping the liquid from the bottom of buffer 78 through the main condenser 66 and back to the top of buffer 78. A modulating valve 102 controls the flow through the main condenser 66 by sensing head pressure of the compressor 62 proximate point 104, upstream of the desuperheating condenser 64. The modulating valve 102 provides protection to the compressor 62, in that as the pressure gets greater, the valve 102 permits more water to flow through the main condenser 66. Modulating valve 101 is connected to the downstream side of main condenser 66, and has an outlet 103 which may be connected to a drain. Modulating valve 101 is also connected to sense the head pressure of the compressor 62 proximate point 104, so that when the head pressure proximate point 104 raises to or above a predetermined value modulating valve 101 opens outlet 103 to drain.

Modulating valve 101 only operates after modulating valve 102 has fully opened and is unable to fully reduce

-7-

head pressure of compressor 62 to an efficient operating pressure.

A further protection for compressor 62 is provided by modulating valve 38, which senses the suction pressure of compressor 62 proximate point 105, permitting more flow of water through the evaporator 58 if the suction pressure of compressor 62 falls below a predetermined and preselected value.

The heating/cooling section 26, referred to herein as an energy handler, may include a blower system 124 for heating or cooling the environment. A thermostat 126 may be used with the blower system 124, and in combination with a warm water pump 122 and a cold water pump 128. In a typical application, heating/cooling section 26 is placed in a room environment, and thermostat 126 regulates the temperature of the room environment. If the thermostat 126 calls for heat it activates warm water pump 122, which pumps warm water through warm conduit 116 and return conduit 120. If the room thermostat 126 calls for cooling, thermostat 126 activates cold water pump 128, which delivers cold water through cold conduit 117 and return cold conduit 119.

In the process of transferring cool air into the room environment via the action of blower system 124, the cool water becomes warmed. This warmed water is returned to cool buffer 42 via conduit 119, resulting in a stratified warming of the water in cool buffer 42. At some point the aquastat 41 associated with cool buffer 42 activates power pack 22, causing circulation of water from cool buffer 42 through evaporator 58. This process again cools the water returned to cool buffer 42 via line 30, and effectively heats the refrigerant flowing through power pack 22. The heated refrigerant passes this accumulated heat onto hot buffer 76 and warm buffer 78 through normal operation of power pack 22, to increase

-8-

the heat content of these buffers. Power pack 22 remains activated until the stratified cooled water returned to buffer 42 reaches the level of aquastat 43, which senses the cool temperature and generates a signal which may deactivate power pack 22. Therefore, in effect, the excess heat accumulated in cool buffer 42 is effectively transferred into warm and hot buffers 78 and 76 respectively. Another way of looking at this overall process is that the cooling action in a room environment results in the heat from the room being transferred from the room to the cool buffer, and from there to the warm and hot buffers, i.e., unwanted room heat is converted into desired hot water and heat energy for other purposes.

FIG. 2 shows a further schematic of heating/cooling section 26, referred to herein as an energy handler, illustrating one form of interconnection for the respective components. Thermostat 126, through the system's electrical circuits, generates actuation signals for activating either cold water pump 128 or warm water pump 122. In either event, signals for blower motor 127 are activated. Blower motor 127 forces air flow through radiator 129, for cold air delivery, and radiator 131, for warm air delivery. In either event, the blower air flows through the radiators and into the room environment as indicated by the arrows. The embodiment of FIG. 2 illustrates a heating/cooling section wherein the respective water supplies are totally isolated from one another. Other forms of heating/cooling section 26 could be utilized in connection with this system. It is preferable to maintain isolation between the respective water supply sources.

The invention is illustrated in a preferred modular form in FIG. 3. The modular form permits usage of remote site energy handler units operated independently of each

-9-

other, or in unison. A plurality of staged power packs extract heat from the cool buffer and/or source water for storage in the hot and warm buffers, and the cooled source water is stored in a cool buffer. For example, a first power pack system 130 is connected to hot and warm buffers 132 and 134 and to cool buffer 135, in a manner similar to that illustrated for a single power pack system in FIG. 1. In addition, a second power pack 136 is also similarly connected, and a third power pack 138 is also similarly connected. The power packs are shown connected to the same source of well water, although they may be supplied through different sources in an alternative embodiment. The well water source conduit is shown in FIG. 3 as conduit 148, and the well water return conduit is conduit 133.

Each of the power packs 130, 136 and 138 are turned on and off through individual aquastats which are symbolically illustrated in FIG. 3. In the case of the warm and hot water buffers, the upper aquastats are set at selected temperatures at different heights in the buffer, and are used to turn on the respective power packs as necessary to transfer sufficient heat from the cool buffer and/or source water to the buffers 132 and 134 as needed. In the cool buffer, the aquastats for the respective systems are found at respective different heights in the cool buffer, and are turned on as necessary to maintain sufficient cool water in the cool buffer 135. In either case, the turn-on temperature of aquastat no. 1 will activate power pack no. 1 for heating and/or cooling, the selected temperature of aquastat no. 2 will activate power pack no. 2 for the same purpose, and the temperature setting of aquastat no. 3 will activate power pack no. 3 for the same purposes. In this manner, an initial demand for buffer heating and/or cooling may be responded to by power pack no. 1, and if

-10-

the load is greater than power pack no. 1 is capable of meeting, a subsequent demand for buffer heating and/or cooling is met by activating power pack no. 2, etc. The compressors associated with the respective power packs may be designed of lighter load-bearing capacity than is typically found in the prior art, and in this manner the overall system will generally require less input energy than prior systems. Prior art systems are characterized by a maximum demand condition which activates the system, and once activated, the prior art system will deliver its heating/cooling capabilities at maximum capacity, rather than at a nominal capacity as may be designed in connection with the present invention.

In the operational sense, the modular system illustrated in FIG. 3 may be connected in a number of different ways. For example, the turn-on temperature setting for the three aquastats in warm buffer 134 can be set to the same temperature, so that their relative positional level in the buffer determines which power pack becomes activated first. Since cooled water returned to the warm buffer 134 enters into the bottom of the warm buffer, the cool water temperature is more or less stratified, and when this stratified cooled water reaches the level of aquastat no. 1 it will activate power pack no. 1. Power pack no. 1 will remain activated until the stratified cool water level returns to approximately the bottom of warm buffer 134, wherein a lower aquastat may generate the turn-off signal. In another and preferably operating convention, a power pack may be turned on by an aquastat in either the cool buffer 135, warm buffer 134, or hot buffer 132; once the power pack is turned on it remains on until all of the turn-off aquastats 4 in the respective buffers sense a return of the stratified water temperature line at the appropriate turn-off water level. While a single power

-11-

pack is activated it simultaneously heats warm buffer 134, hot buffer 132, and cools cool buffer 135, and the respective aquastats may be wired to cause the power pack to remain on for so long as any turn-off aquastat does not sense the appropriate water temperature at its stratified level. This operating convention eliminates excess cycling of the power packs, for a power pack will remain on until all buffers have been returned to their respective satisfactory water temperature conditions.

Another operational scheme which might be utilized with the modular system of FIG. 3 is to connect the respective power packs to the respective buffers so that a particular power pack always turns on first in response to a particular buffer's water temperature needs. In other words, power pack no. 1 could be connected to aquastat no. 1 in cool buffer 135; power pack no. 2 could be connected to aquastat no. 1 in hot buffer 132; power pack no. 3 could be connected to aquastat no. 1 in warm buffer 134. Under this operational scheme, power pack no. 1 would always be the first power pack activated in response to a need for further cooling of the water in cool buffer 135; power pack no. 2 would be the first power pack activated in response to a need for further hot water in hot buffer 132; and power pack no. 3 would be the first power pack activated in response to a need for warm water in warm buffer 134. Once activated, any of these power packs would continue operating until the respective cool, hot and warm temperature needs were all met in all of the buffers.

FIG. 4 shows a form of construction which can advantageously utilize the invention, and for which the invention may provide a typical savings in annual heating and cooling costs in the range of 60-75 percent. FIG. 4 represents a three-story structure, typically a motel or

-12-

commercial office building construction, having 50,000 square feet or greater of usable floor space. It is presumed that the construction of FIG. 4 is made according to currently commercial standards, and, if utilized as a motel or hotel structure, has a lobby entrance 152 into a first floor 155, which also encloses a lobby and lounge area, an atrium area, a pool area, various mechanical and facilities rooms, laundry, and other rooms which are commonly found in motel structures. A second floor 156 and a third floor 157 typically are constructed to provide a number of living units, either rooms or suites, which may be constructed around the periphery of the structure, facing inwardly toward a three-story atrium. The atrium is crowned by a glass roof section 154, thereby providing exposure to the interior of the structure to sunlight. In typical structures such as is illustrated in FIG. 4 it is not unusual to provide 3,750,000 Btus per day of heat energy for the hot water requirements of the building. This heat energy is typically delivered in high concentrations during a two-hour period in the morning and during a two-hour period in the evening, when demand for hot water is the highest. Such a demand cycle would require a water heating capacity of 1,000,000 Btus per hour with prior art technology. The normal building heat loss is approximately 550,000 Btus per hour (Btuh) during the coldest days, if the building is located in a cold climate, such as is found in the northern United States. Infiltration and make-up air generally requires about 300,000 Btuh in order to maintain building comfort and air circulation. The individual rooms or suites in the building are typically heated and cooled with self-contained conditioning units in each room. The room heating and cooling demands are a function of the climate, the room exposure, the number of people

-13-

occupying the room, and the time of day. It is not unusual for each room to require approximately 5,000 Btuh of heat energy. Because conventional heating and cooling systems must be scaled to provide and meet peak demand requirements, the capacity of the heating and cooling units must be inherently oversized. This problem is typically handled by peak demand units merely cycling more or less frequently, depending upon heating and cooling needs. Such systems are always either fully on or fully off, and when fully on are delivering their maximum energy capabilities, and consuming maximum energy for driving power.

FIG. 5 shows a typical floor plan for the first floor 155 of the structure of FIG. 4. The floor plan includes a center atrium area which extends throughout the three-story structure to the glass roof section 154. The first floor also includes a lobby and lounge area, a pool area, a number of stairwells 158, one or more equipment rooms 162, conference and meeting rooms, a number of living units 160, and various other facilities such as restrooms, utility rooms, laundry rooms, storage rooms, etc. Each of the various different rooms and areas shown on FIG. 5 have different heating and cooling needs, and a well-designed heating and cooling system will properly accommodate these needs. For example, each of the living units 160 are typically designed for an average occupancy of three persons, and require heating and make-up air energy of 4,000-5,000 Btuh. Air circulation requirements demand about 15 cubic feet per minute per person of air circulation, of which one third must be fresh air from outside. Each of the stairwells 158 will typically require about 5,000 Btuh of heating/cooling energy. Service rooms such as entrance areas, restrooms, laundries, mechanical rooms, typically require about 4,000 Btuh. The lounge and lobby area will

-14-

have energy demands proportionate to their size and other factors, but several energy handlers, on the order of 4,000 Btuh. A swimming pool area requires 75,000 Btuh, but since the air must be constantly dehumidified, it is possible to constantly recover about 30,000 Btuh from the dehumidification process. The atrium area may suffer a heat loss of about 250,000 Btuh, including the make-up air requirements. Each conference room may require from 0 to 60,000 Btuh of air conditioning in the heating season, if the conference room is fully utilized and has its capacity occupancy, and up to 90,000 Btuh air conditioning during peak summer demand.

FIG. 6 shows a typical floor plan for a second floor 156 or a third floor 157 of the structure shown in FIG. 4. The upper floors of the structure will also have a center atrium opening, but will be typically designed for more or less exclusive living unit construction. These floors will usually have hallways 164, and a plurality of living units 160 having access doors entering into the hallway. A representative floor plan of a single unit 160 as shown in FIG. 7, wherein the living unit may be subdivided into a living room section 166, a bath section 167, and a bedroom section 168. When all of the heating needs of this building are taken into consideration, it requires a maximum average design heating capacity of about 900,000 Btuh. Note that this is less than the domestic hot water peak demand, which alone requires 1,000,000 Btuh. The heating and cooling needs for such a structure are typically met by domestic hot water heaters, a central heating plant and boiler system, a central cooling tower, and multiple heat pumps distributed throughout the various rooms and heating/cooling zones in the structure. It is common for such systems to run a water supply loop throughout the various building areas,

-15-

wherein water is maintained in constant flow at temperatures ranging from 60°-90° F.

An embodiment of the invention will now be described, with reference to FIGS. 4-7, in order that the full features and advantage of the invention may be fully understood. Reference will be made generally to power packs, buffers, and energy handlers in the context previously described. The buffers and power packs are placed in an equipment room 162, wherein three power packs A, B, C, are designated by reference numeral 170. Each of the power packs A, B, C, are driven by a 20 horsepower (hp) compressor unit, wherein the total energy capacity of all three power packs is approximately 900,000 Btus per hour. A cool buffer 140 has a liquid storage capacity of 4,800 gallons, as does a warm buffer 142. A hot buffer 144 has a liquid storage capacity of 1,600 gallons. If power pack A is designated as the primary energy provider, under typical annual average energy demands it will be required to operate approximately 85 percent of the time. If power pack B is designated as the secondary energy provider, under the same annual average energy demands it will be required to run about 50 percent of the time; if power pack C is designated as the tertiary energy provider, under the same annual average energy demands it will be required to run about 15 percent of the time. In other words, normal energy demands will in most cases be wholly satisfied by power pack A; longer term energy demands will be satisfied by the combination of power packs A and B, and the occasional extended energy demands will be satisfied by the combination of power packs A, B, and C all operating simultaneously. When power packs A, B, and C are all operational simultaneously, they can output about 900,000 Btuh.

-16-

Each living unit 160 has an energy handler 161. Cool water lines 145 and 146 are connected throughout the structure, typically running above the ceiling down the various hallways 164. Similarly, warm water lines 149 and 150 are connected throughout the structure. Energy handler 161 is coupled in parallel to the respective cool water lines 145 and 146, and warm water lines 149 and 150, and thermostatic-controlled valves permit water flow through energy handler 161 via the lines. The thermostat controlling energy handler 161 is typically located in a central position within living unit 160. In addition, a hot water line (not shown) is run throughout the structure for coupling into the various hot water delivery faucets required for common usage. The cool water and warm water used to supply lines 145 and 146, and 149 and 150, are coupled to cool buffer 140 and warm buffer 142 respectively. The hot water lines are coupled to hot buffer 144. The cold, warm and hot buffers are respectively coupled to the power packs as has been previously described herein.

Other energy handlers are similarly connected to the various heating/cooling zones throughout the structure, including the lobbies, conference rooms, pool and pool area, spa, atrium, stairwells, utility rooms, etc. The principles of connection and operation of each of these energy handlers is the same as for the energy handler 161 in a living unit 160, and each of the separate energy handlers may have its own thermostatic control. Heating energy handlers can also deice driveways or walkways, reheat air cooled for dehumidification purposes, heat industrial chemicals, and heat swimming pools and spas, etc. Cooling energy handlers can also cool industrial chemicals, dehumidify air, etc.

The instantaneous energy demands of any room within the structure is met by the thermostat in that particular

-17-

room generating an activation signal to its energy handler; the energy handler then couples itself into the cold/warm water line and, typically through a water/air heat exchanger, delivers heated/cooled air into the room. If the room is heated, heat is transferred from the warm water supply line 149 into the room environment, and the cooled water is directed to return line 150. If cooling is demanded, cool air is delivered into the room through a similar heat exchange process, and cool water supply line 145 provides the cool water and cool water return line 146 is incrementally warmed to the extent that the heat transfer process takes place. Since cool water return line 146 and warm water return line 150 pass throughout the entire structure, terminating in the respective warm/cool buffer, the temperature of the water in the buffers is incrementally affected by the process. As the stratified temperature in a buffer departs from a predetermined point, it activates power pack A to restore the temperature to its set point position. Power pack A also, through its operation, tends to restore the temperatures of the other buffers to their set point position. If the heating/cooling demand causes a respective buffer to depart past a second predetermined set point, power pack B is activated to assist in the restoration of temperature in the affected buffer. Likewise, under extremely peak demand conditions, if the temperature in a buffer departs from a third predetermined set point power pack C may be activated. In a preferred embodiment, for example in a warm buffer, the respective temperatures for activating each of the power packs A, B, C may be sensed at different levels in the warm buffer tank, the power pack A temperature sensor being lowest, the power pack B temperature sensor being an intermediate point, and the power pack C temperature sensor being a higher point. Therefore, as the

-18-

temperature of warm buffer drops, the stratified cooler water is first sensed by the power pack A temperature sensor, and if the temperature of the buffer continues to drop the stratified temperature is sensed by the power pack B sensor, and if the temperature continues to drop the stratified temperature is sensed by the sensor for power pack C, because as the overall temperature in the warm buffer drops the cooler water strata will be sensed at higher and higher levels within the tank. The inverse process is used to activate power packs by sensors attached to the cool buffer.

It should be recognized that ideally the heating of the hot buffer is assisted by virtue of the fact that its input is connected to the warm buffer; therefore, the water temperature input into the hot buffer is already elevated, and the hot buffer need only to increase incrementally the temperature of its water. Likewise, it should be recognized that water from the warm and hot buffers can be mixed through suitable valving, in order that an excess stored accumulation of hot water can be used to assist the warm water demand needs under certain conditions. Likewise, if the temperature in the hot water buffer increases beyond the range deemed satisfactory or safe for hot water demand needs, the warm water from the warm buffer can be mixed into the hot water to provide hot water delivery at the optimum delivery temperature.

It is also apparent that, at certain times during the day, the living units along the south side of the building may require cooling air, while the living units along the north side of the building may require heating air. In this situation, the cool buffer may be simultaneously delivering cooling energy to the south side of the building and to the dehumidifier while the warm buffer is delivering heat energy to the north side

-19-

of the building and the pool, etc. The system is in effect merely passing the recovered heat from the cooling requirements of the building to the heating requirements of the building. The transformation of this heat energy takes place through the buffer system, but the process may take place without any short term demand on the power packs themselves.

It is therefore seen that the respective buffers provide instantaneous and short-term peak energy requirements to satisfy all the energy handlers' heating and cooling demands in their respective zones of the building at any instant in time; the power packs supply energy to meet the overall average energy consumption of the building. In this manner, the power packs may be sized merely for average consumption, and further may be staged so as to accommodate short-term perturbations to the average energy demands.

Systems currently existing in the art do not have the energy storage capability of the heating/cooling buffer system of the present invention to meet peak heating/cooling demands without sizing the refrigeration system for those peak demands. Present systems in the art also do not allow energy transfer between buffers, which provides for very efficient system operation with lowered water source requirements or usage. The present invention also allows for completely independent functioning of the energy handlers, and in a typical installation some energy handlers may be cooling a room environment while other energy handlers are heating a room environment. The cooling energy handlers retrieve the energy recovered from the cooling process in the cool buffer, where it is effectively transferred into the warm and hot buffers for subsequent usage in an area which has a heating requirement.

-20-

The modular form of the invention illustrated in FIG. 3 may also incorporate the specific control functions which are described in my U.S. Patent 4,633,676, which is incorporated by reference herein. Other forms and alternatives of the present invention may be devised, in addition to the preferred embodiments described herein, without departing from the spirit and scope of the invention.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof, and it is therefore desired that the present embodiment be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than to the foregoing description to indicate the scope of the invention.

-21-

WHAT IS CLAIMED IS:

1. A system for transferring heat energy from a source of liquid for storage and heating, and for simultaneously storing the source liquid for cooling, comprising
 - a) means for providing a refrigeration cycle, including means for evaporating refrigerant, means for condensing refrigerant, and means for effectuating heat transfer to and from the refrigerant;
 - b) means for providing a flow of said source liquid in heat transfer relationship to said means for evaporating refrigerant, wherein said means for effectuating heat transfer removes heat from said source liquid and transfers it to said refrigerant;
 - c) means for storing said heat-removed source liquid;
 - d) means for transferring said heat-removed source liquid from said means for storing to a means for cooling air, wherein said source liquid effectuates said means for cooling air;
 - e) means for providing a flow of liquid into heat transfer relationship with said means for effectuating heat transfer from said refrigerant, thereby heating said liquid;
 - f) means for storing said heated liquid;

-22-

- g) means for transferring said heated liquid from said means for storing said heated liquid to a means for heating air, wherein said heated liquid effectuates said means for heating air; and
- h) control means for actuating said means for providing a refrigeration cycle, said control means being responsive to at least one temperature in each of said means for storing.

2. The system of claim 1, wherein the means for condensing refrigerant further comprises a desuperheating condenser and a main condenser serially connected.
3. The system of claim 2, further comprising first means for providing a flow of water into heat transfer relationship with said desuperheating condenser, and first means for storing said heated water; and second means for providing a flow of liquid into heat transfer relationship with said main condenser, and second means for storing said heated liquid.
4. The system of claim 3, wherein said first and second means for storing further comprise hot and warm liquid buffers respectively.
5. The system of claim 1, wherein said means for cooling air and said means for heating air further comprise a single heat transfer apparatus.
6. The apparatus of claim 1, further comprising a modulating valve coupled to said means for providing

-23-

a flow of said source liquid, and control means for operating said modulating valve coupled to said means for evaporating refrigerant.

7. The apparatus of claim 6, further comprising controllable valve means for selectively transferring said source liquid having heat removed into said means for storing said heat-removed source liquid.
8. The apparatus of claim 4, further comprising a water well for providing said source liquid.
9. The system of claim 8, wherein said means for cooling air and said means for heating air further comprise a single heat transfer apparatus.
10. The apparatus of claim 9, further comprising controllable valve means for selectively transferring said source liquid having heat removed into said means for storing said heat-removed source liquid.
11. A heating and cooling system adapted for simultaneous and/or independent delivery of heat transfer liquid from a cool, warm and hot buffer to a plurality of independently controllable energy handlers, each energy handler being capable of heat transfer between said heat transfer liquid and a local environment, comprising
 - a) a source of heat transfer liquid;
 - b) means for providing a refrigeration cycle, including means for evaporating refrigerant,

-24-

means for compressing refrigerant, and a plurality of heat transfer means for effectuating heat transfer to and from said refrigerant;

- c) means for coupling said source of heat transfer liquid to a first of said plurality of heat transfer means, in heat transfer relationship to said means for evaporating refrigerant, whereby heat is transferred from said heat transfer liquid to said refrigerant, thereby cooling said heat transfer liquid;
- d) cool buffer means for storing said cooled heat transfer liquid, including means for selectively transferring cooled heat transfer liquid from said means for storing to said plurality of independently controllable energy handlers;
- e) a further source of heat transfer liquid;
- f) means for coupling said further source of heat transfer liquid to a second of said plurality of heat transfer means, in heat transfer relationship to said compressed refrigerant, whereby heat is transferred from said compressed refrigerant to said heat transfer liquid, thereby heating said heat transfer liquid;
- g) warm buffer means for storing said heated heat transfer liquid, including means for selectively transferring heated heat transfer liquid from said means for storing to said plurality of independently controllable energy handlers;

-25-

- h) means for coupling said further source of heat transfer liquid to a third of said plurality of heat transfer means, in superheated heat transfer relationship to said compressed liquid, whereby superheated energy is transferred from said compressed refrigerant to said heat transfer liquid, thereby heating said heat transfer liquid to a temperature higher than the refrigerant condensing temperature;
- i) hot buffer means for storing said superheated heat transfer liquid, including means for selectively removing superheated heat transfer liquid from said means for storing;
- j) means for selectively monitoring the respective temperatures in the means for storing cooled heat transfer liquid, the means for storing heated heat transfer liquid, and the means for storing superheated heat transfer liquid, and for activating said means for providing a refrigeration cycle at predetermined temperatures; and
- k) means for selectively monitoring the respective temperatures of the local environments of the energy handlers, including means for activating flow of heat transfer liquid from a respective cool and warm buffer to an energy handler in response to predetermined monitored temperatures.

12. The system of claim 11, including temperature responsive means for mixing said heated and said superheated heat transfer liquid.

-26-

13. The system of claim 12, whereby said means for providing a refrigeration cycle further comprises a plurality of stages.
14. The system of claim 13, further comprising a means for monitoring the respective temperatures in the means for storing cool, warm and superheated heat transfer liquid, associated with each of the stages.

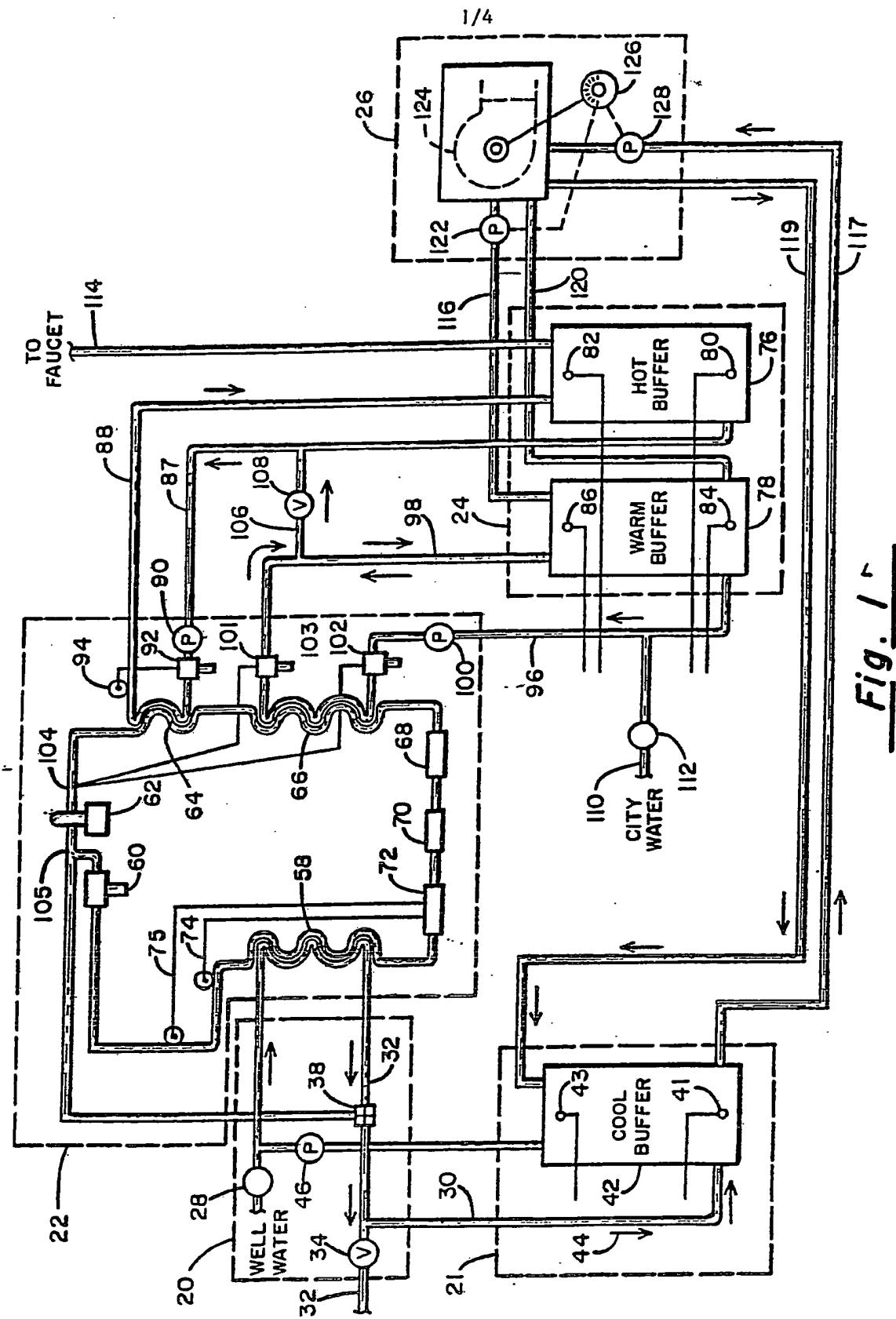
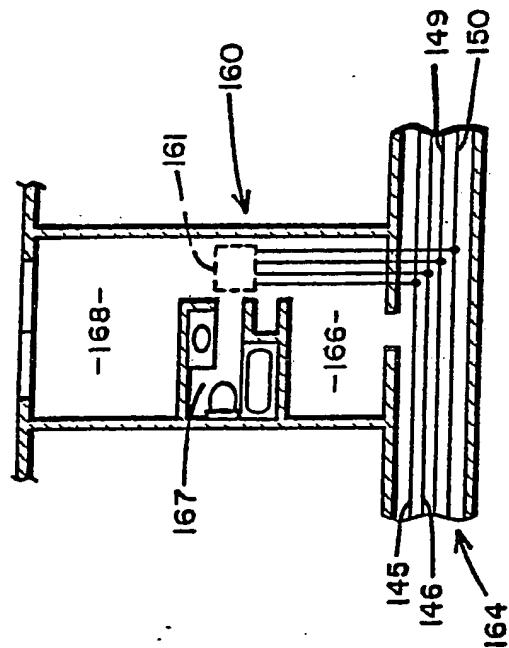
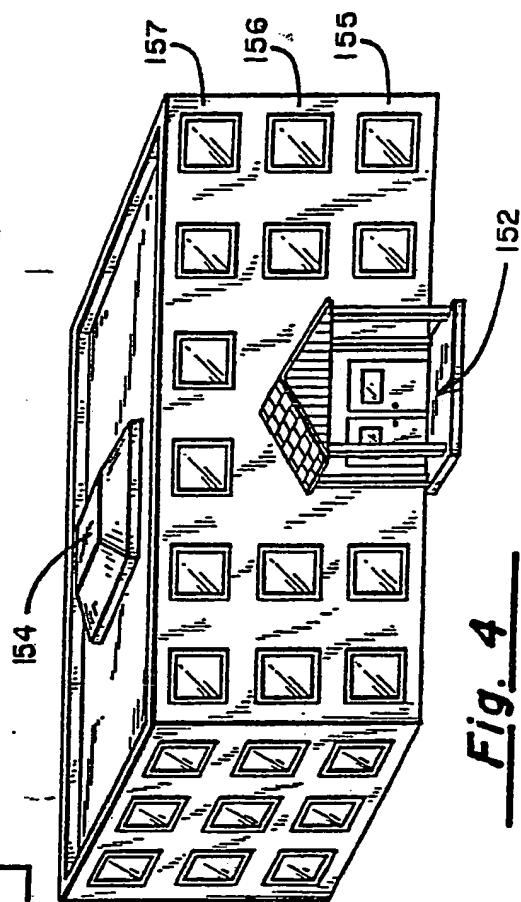
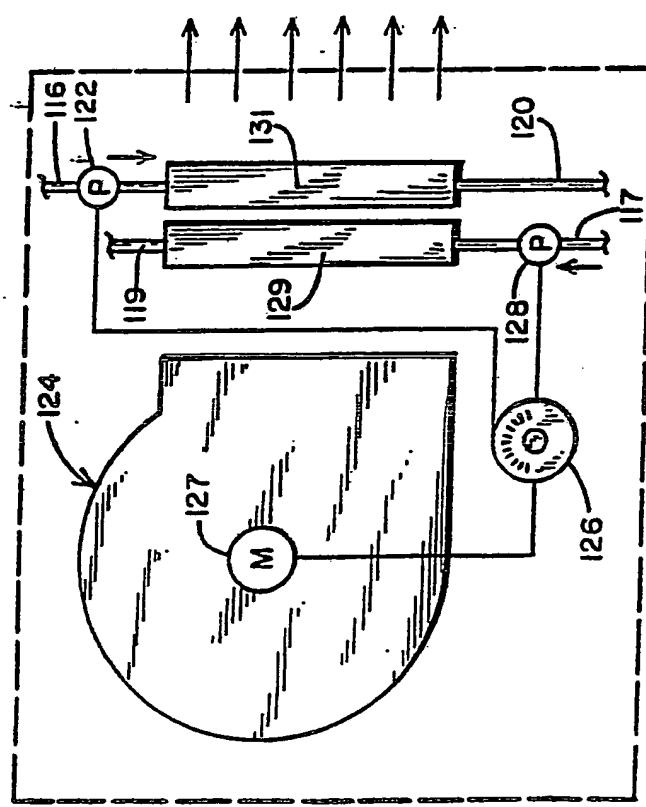


Fig. 1'

2/4

Fig. 7Fig. 4Fig. 2

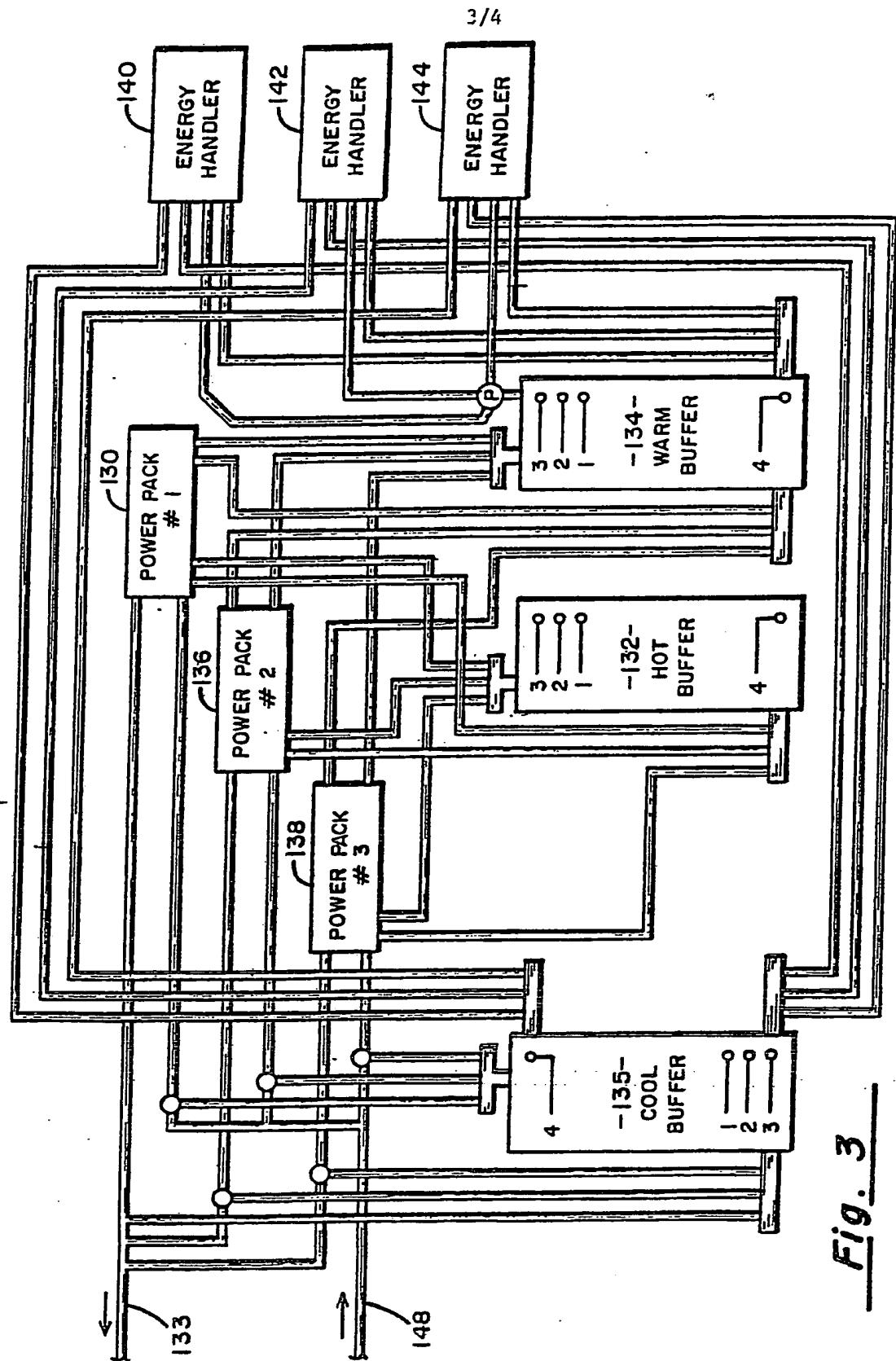
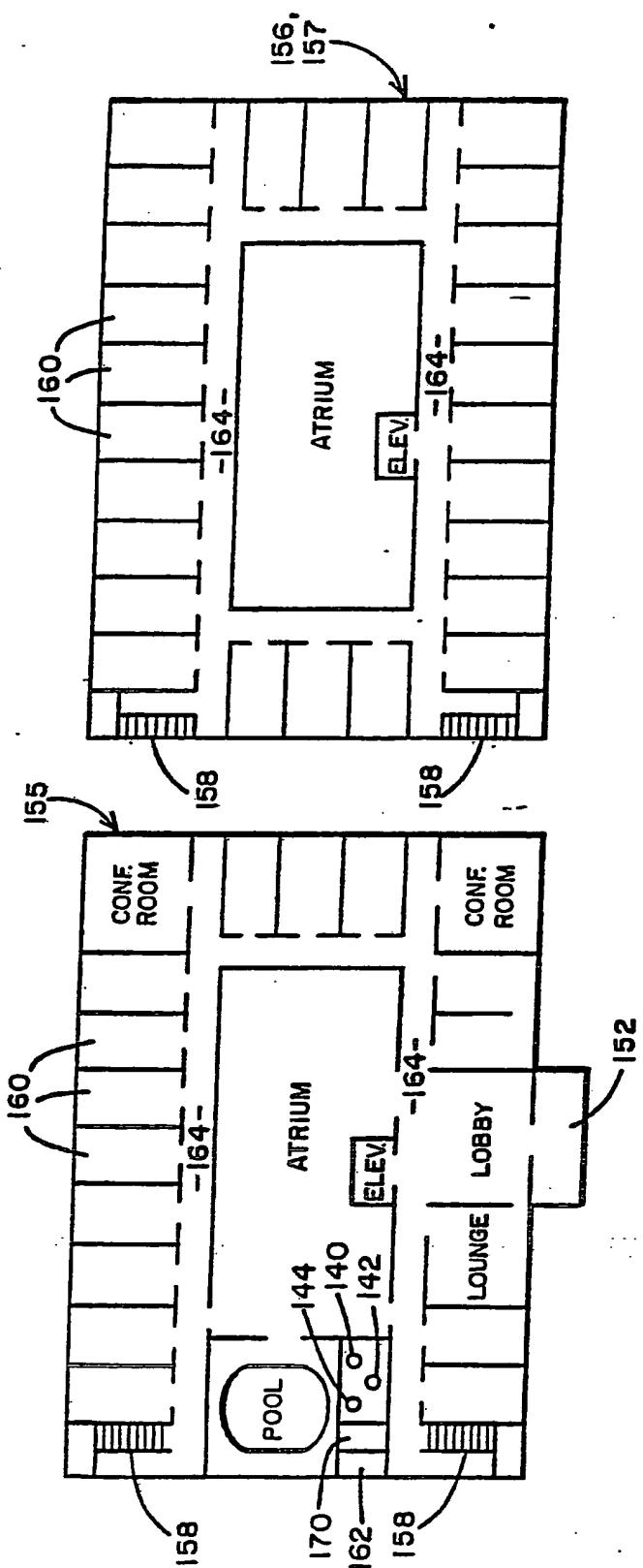


Fig. 3

4/4

Fig. 6Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US 87/02891

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (4): F25D 17/02; F25B 1/10
62/201, 185

II. FIELDS SEARCHED

Minimum Documentation Searched ⁷

Classification System	Classification Symbols
U.S.	62/201,185,260,238.1,238.6,238.7,430,434,435,436 62/510,228.5,196.2,180,181,183,184,179 165/902;236/2B

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched ⁸

III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹

Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 2,935,857 (MCFARLAN) 10 May 1960 See the entire document.	1,5,8,9,11, 13
Y	US, A, 4,134,273 (BRAUTIGAM) 16 January 1979 See the entire document.	1,6,11
Y	GB, A, 2,016,668 (BRADSHAW) 26 September 1979 See Fig. 3 and page 4 line 116 to page 5, line 43.	1,11,13
Y	US, A, 4,559,788 (MCFARLAN) 24 December 1985 See the entire document.	1,5,9,11,13
Y	US, A, 4,633,676 (Dittell) 6 January 1987 See the entire document.	1-6,8,9,11- 14
Y	US, A, 4,382,368 (Dittell) 10 May 1983 See the entire document.	2-5,8,9,11

* Special categories of cited documents: ¹⁰

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"Z" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
07 April 1988	18 MAY 1988
International Searching Authority ISA/US	Signature of Authorized Officer Harry Tanner

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 3,069,867 (RINGQUIST) 25 December 1962 See column 3, lines 55-68.	5,9
Y	US, A, 4,165,036 (MEEKLER) 21 August 1977 See entire document.	7,8,10
Y	US, A, 3,996,759 (MECKLER) 14 December 1976 See entire document.	7,10
Y	JP, A, 60-233443 (IMABAYASHI et al) 20 November 1985, see entire document.	14
Y	JP, A, 55-85840 (HAGIWARA) 28 June 1980 See entire document.	14

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.